

CLAIMS

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5 1. A micromotor comprising:

a piezoelectric element including a common electrode and a plurality of other electrodes formed thereon and including at least a first and a second electrode group, each group including at least one electrode, wherein the piezoelectric element causes motion in a first direction when a voltage is applied between the first electrode group and the common electrode and wherein the piezoelectric element causes motion in a second direction when a voltage is applied between the second electrode group and the common electrode;

10 an voltage source that electrifies the common electrode; and

at least two switches separately connected between the first and second electrode groups and a low voltage, said switches being activatable to connect one of said first and second electrode groups to the low voltage to cause selective motion in the first or second directions.

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2. A micromotor according to claim 1 wherein the low voltage is substantially ground.

3. A micromotor according to claim 1 or claim 2 wherein the applied voltage is an AC voltage.

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4. A micromotor according to any of the preceding claims wherein the piezoelectric element comprises a rectangular piezoelectric plate having first and second faces wherein the common electrode is formed on the first face and the first and second groups of electrodes are formed on the second face.

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5. A micromotor according to claim 4 wherein the first and second groups of electrodes each comprises two electrodes situated in opposite quadrants of the second face.

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6. A micromotor according to any of the preceding claims wherein the micromotor comprises a motive surface and wherein motion is induced in a surface of a workpiece pressed against the motive surface when the piezoelectric element is electrified as aforesaid.

7. A micromotor comprising:

an ultrasonically vibrating element; and

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and 8*

a drive circuit comprising:

an oscillating voltage source connected to and electrifying at least one electrode of said ultrasonically vibrating element to cause a mechanical displacement of a portion thereof; and

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a discrete switch arrangement attached to at least one additional electrode of said ultrasonically vibrating element to which said oscillating voltage is not connected which switch arrangement selects the direction of said displacement.

8. A micromotor according to claim 7 wherein the ultrasonically vibrating element
10 comprises a piezoelectric element.

9. A micromotor according to claim 7 or claim 8, wherein:

the at least one additional electrode comprises a plurality of electrodes applied to a first face of said vibrating element; and

15 the at least one electrode comprises a common electrode applied to a second face of said element.

10. A micromotor according to claim 9 wherein the discrete switch arrangement selectively applies voltage between a first group of said plurality of electrodes and said
20 common electrode to cause displacement in a first direction, said first group including at least one electrode.

11. A micromotor according to claim 10, wherein the discrete switch arrangement selectively applies voltage between a second group of said plurality of electrodes and said
25 common electrode to cause displacement in a second direction, said second group comprising at least one electrode.

12. A micromotor according to any of the preceding claims wherein said discrete switching arrangement comprises a pair of switches connected to apply voltages across said element to drive current through said element, and controls for selectively operating said switches to select the direction of said displacement.
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13. A micromotor according to claim 12 wherein said switches of said discrete switching arrangement are solid state switches.

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14. A micromotor according to claim 12 or 13 wherein said switches of said discrete switching arrangement comprise transistorized switches.

5 15. A micromotor according to claim 14 wherein said switches of said discrete switching arrangement are Mosfet transistors.

16. A micromotor according to claim 11 wherein said discrete switch arrangement comprises:

10 a first Mosfet connected between a first voltage and said first group of electrodes;
a second Mosfet connected between said first voltage and said second group of electrodes, said common electrode being connected to a second voltage, and
a control that selectively operates said Mosfet switches to selectively apply said first voltage to the first electrode group or to said second electrode group.

15 17. A micromotor according to claim 16 including a source of control voltages selectively applied to the gates of said first and second Mosfet transistors for selectively switching said first or said second Mosfet transistors from the non conducting state to the conducting state.

20 18. A micromotor according to claim 16 or claim 17 and including a pair of diodes, one of which is connected across each said Mosfet transistor.

19. A micromotor according to claim 18 wherein the diodes are connected such that they conduct DC current toward the micromotor.

25 20. A micromotor according to any of claims 17-19 wherein, when the transistor is off, one end of the Mosfet is at a DC voltage equal to the peak of the oscillating voltage and the oscillating voltage is impressed across the Mosfet transistor, such that the voltage across the transistor is substantially unipolar.

30 21. A micromotor according to any of the preceding claims wherein said source comprises an inverter.

22. A micromotor according to claim 21 wherein the inverter is a forward-flyback inverter.

23. A micromotor according to claim 22 wherein said forward-flyback inverter comprises:
a magnetic element having a primary winding and a secondary winding, said primary
winding being connected between a first inverter voltage and one side of an inverter operating
5 switch, the other side of said inverter operating switch connected to a second inverter voltage
so that when said inverter operating switch is in the conductive stage, current flows through
said primary and when said inverter operates switch is in a non conductive state substantially
no current flows through said primary; and
a control voltage source which selectively turns said inverter operating switches on or
10 off, the secondary of said magnetic element being connected to said discrete switching
arrangement.
24. A micromotor according to claim 23 wherein said inverter operating switches are solid
state switches.
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25. A micromotor according to claim 23 wherein said inverter operating switches are
transistorized switches.
26. A micromotor according to claim 23 wherein said inverter operating switches are
20 Mosfet transistors, and comprising:
circuitry that causes said inverter output to resonate at substantially the mechanical
resonant frequency of said piezoelectric element.
27. A micromotor according to claim 26 wherein said circuitry that causes said inverter
25 output to resonate at substantially the mechanical resonant frequency of the piezoelectric
comprises a capacitor bridging said switch and in series with the primary of the magnetic
element, said capacitor operating in conjunction with the capacitance of said ultrasonically
vibrating motor to turn said magnetic element to resonate at substantially the mechanical
resonant frequency of the motor.
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28. A micromotor according to claim 21 wherein said inverter is a push-pull inverter.
29. A micromotor according to claim 28 wherein said push-pull inverter comprises a
transformer, having a primary and a secondary;

a series inductor connecting a first inverter input to a mid part of the primary of said transformer,

the secondary of said transformer connected to said discrete switching arrangement and one side of the primary of said transformer being connected through a first push-pull inverter switch to a second inverter input,
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the other side of said primary of said transformer being connected through a second push-pull inverter switch to said second input.

30. A micromotor according to claim 29 wherein said first and second push-pull switches
10 are solid states switches.

31. A micrometer according to claim 30 wherein said first and second push-pull inverter switches are transistorized switches.

15 32. A micromotor according to claim 30 wherein said first and second push-pull inverter switches are Mosfet type switches.

33. A micromotor according to any of claims 29-31 wherein the capacitance of said ultrasonic motor and the inductances of the series inductance and of said transformer match the electrical circuit to the mechanical resonance of said piezoelectric element.
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34. A micromotor according to claim 33 wherein the first and the second push-pull inverter switches are each selectively operated by control voltages.

25 35. A micromotor according to claim 34 wherein the control voltages are square wave voltages.

36. A micrometer according to any of claims 29-35 wherein said push-pull inverter includes a buck section for controlling the amplitude of the voltage connected to said primary of said transformer.
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37. A micromotor according to claim 36 wherein said buck section includes:
a series buck section switch connected between the first input of the inverter and the series inductor;

a diode connected between an output of the buck section switch and said second input of the inverter and,

a control voltage operative to cause the buck section switch to conduct.

5 38. A micromotor according to any of claims 29-37 wherein the second input is ground.

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39. A micromotor according to any of claims 29-38 wherein the first input is electrified with a DC voltage.

10 40. A method of supplying switchable AC power to a load comprising:
connecting a first terminal of an AC power source to one side of the load;
connected a Mosfet transistor between a second terminal of the AC power source and
the other side of the load; and
selectively supplying power to the load by applying a voltage between a gate of the
15 Mosfet and the second AC terminal.

41. A method according to claim 40 and including connecting a diode across the Mosfet transistor.

20 42. A method according to claim 41 wherein the diode is connected such that it conducts current between the second terminal and the other side of the load.

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25 43. A method according to any of claims 40-42 and including placing a capacitor in series with the load.

44. A method according to claim 43 wherein the load does not comprise a DC blocking capacitor.

30 45. A method according to any of claims 40-44 wherein, when the transistor is off, one end of the Mosfet is at a DC voltage equal to the peak voltage of the AC source and AC voltage of the AC source is impressed across the Mosfet transistor, such that the voltage across transistor is substantially unipolar.